INSTRUCTION MANUAL

MODEL 530

TYPE-ALL SYSTEM

KEITHLEY INSTRUMENTS

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SPECIFICATIONS

VOLTMETER RANGE: ±1 microvolt per digit to ±1000 volts full scale in seven decade ranges

VOLTMETER ACCURACY: ±0.1% of reading, ±1 digit on all ranges

CURRENT SOURCE RANGE: 10^{-7} ampere full range to 10^{-1} ampere in seven decade ranges

CURRENT SOURCE ACCURACY: ±0.5% of reading, ±0.05% of full range

RANGE OF TYPING MODE: 10^{-3} to 10^{4} OHM-CM
TYPING MODES: Rectification
Thermoelectric

PROBE CONFIGURATION REQUIRED: Four-point in-line probe

EQUIPMENT SUPPLIED:
Keithley Model 225 Current Source
Keithley Model 163 Digital Voltmeter
Keithley Model 530 Type-All Switching
Keithley Model 8201 Cable Assembly

SUPPLIED ACCESSORY:
Model 5301 Test Lead (two pieces).

SECTION 1. GENERAL DESCRIPTION

1-1. GENERAL. The Keithley Model 530 Type-All System is an electronic system designed for measurement of resistivity and determination of conductivity type of a semiconductor. The Keithley System contains a precision current source, digital microvoltmeter, and other circuitry needed for resistivity and typing determinations. The Model 530 must be used with a standard four-point in-line probe to make contact to the sample.

1-2. RESISTIVITY MEASUREMENT. Resistivity of a semiconductor material can be easily determined by applying a known current through the sample. The resultant voltage drop across the sample is then measured using a sensitive microvoltmeter. However, since the resistivity is a function of slice geometry and probe spacing, several correction factors must be used. These correction factors are explained in ASTM Designation: F84-70*. The basic factors which need to be considered are:

Slice diameter	D	mm
Average probe separation	$\overline{S}$	mm
Specimen thickness	W	mm

NOTE: All dimensions are assumed to be in metric units unless otherwise specified.

The Keithley Model 530 System provides the convenience of selectable current so that the voltage reading can be scaled to read directly in terms of OHM-CM (where 1 mV = 1 OHM-CM). A computer program and printout (see Table 2-1) are provided in the Appendix of this Instruction Manual for calculating the proper current using BASIC language.

**Standard Method for Measuring Resistivity of Silicon Slices With A Collinear Four-Probe Array. ASTM F84-70*

1-3. CONDUCTIVITY TYPE DETERMINATION. The conductivity type, or sign of the majority carrier is a fundamental property of a semiconductor sample. The Model 530 System utilizes two methods for quickly determining the semiconductor type. This system is basically described in an article entitled "Type-All System for Determining Semiconductor Conductivity Type" from Solid State Technology/March, 1971*. The System incorporates rectification and thermoelectric typing techniques in a system that makes the two methods compatible. A four-point in-line probe is used to contact the sample.

a. Rectification Mode. Rectification is the mode of operation initially used. An ac voltage is imposed across two of the probe points as shown in Figure 3d. A second set of probe points is used to sense the polarity of the generated voltage. The polarity depends on how the voltage is generated and on the conductivity type of the material. If the probe points are providing a rectification effect at the contact point to the semiconductor, then a dc voltage between points B and D will result. The polarity of the rectification depends on the conductivity type of the material. Back biasing is achieved on a metal-to-n-type semiconductor diode when the semiconductor is at a positive potential with respect to the metal. A negative potential results in a back-biased junction for p-type semiconductor. Thus, the semiconductor type is simply a function of the polarity of the voltage monitored by the microvoltmeter. For certain resistivities the quality of rectification degenerates such that the usefulness of this mode decreases. An acceptable rectification action occurs for voltage readings above 0.5 mV. For voltages less than 0.5 mV the thermoelectric mode should be used.

**W. A. Keenan, C. P. Schneider, C. A. Pillus, "Type-All . . .", Solid State Technology, March 1971, pg. 51-56.*

b. Thermoelectric Mode. In this mode the ac voltage impressed across the input probe points increases the temperature near the point of contact by joule heating of the semiconductor. A Seebeck voltage is generated between a hot and cold probe point where ΔV is the voltage generated across two regions of material whose temperatures differ by ΔT. The physical process that generates the Seebeck voltage is the diffusion of the thermally generated carriers from the hot region of the material to the cold region. The carriers will diffuse from high-to-low-concentration regions, in particular from the hot to the cold probe. This diffusion creates a non-equilibrium carrier concentration in the cold region which generates an electric field, opposing further diffusion. This diffusion of carriers from the hot to the cold probe continues until the generated electric field is sufficient to overcome the tendency of the carriers to diffuse. For example, in p-type material, the thermally generated holes diffuse to the cold probe, building up a positive space charge which retards further diffusion. As a result, the cold probe is more positive than the hot probe. The use of four probe points permits a separation of the ac power source and the voltage-detection functions. In the Model 530 the voltage sensing is performed by the Model 163 digital voltmeter which provides speed and convenience of a digital display with automatic polarity indication. The thermoelectric mode utilizes all four probe points as shown in Figure 3e.

TABLE 1-1.
Summary of Model 530 Controls.

Control	Functional Description	Circuit Desig.
POWER Switch	Applies power to Model 530 System including auxiliary power receptacles.	S101
PROBE Switch	Selects either "A" or "B" probe inputs on the rear panel.	S105
FUNCTION Switch	Selects function for resistivity or typing determination.	S103
STANDBY Position	No connections are made to probe.	
CURRENT Position	Connects current source to enable a calibration check.	
V_{FWD} Position	Connects probe to measure resistivity.	
V_{REV} Position	Connects probe to measure resistivity. (reversed polarity)	
TYPE (RECT)	Connects probe for typing using Rectification Method.	
TYPE (THERM)	Connects probe for typing using Thermal Method.	
CURRENT SHUNT Switch	Sets resistivity range.	
HI Terminal	Voltmeter High Input	J106
LO Terminal	Voltmeter Low Input	J107

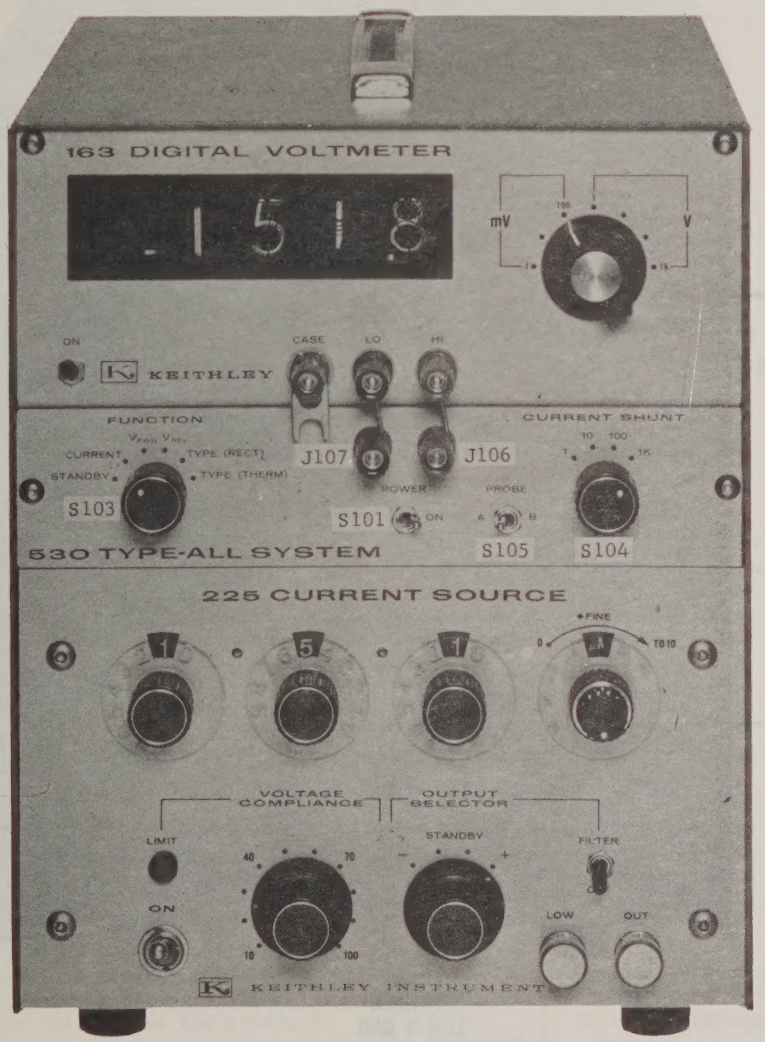


FIGURE 1. Controls and Terminals

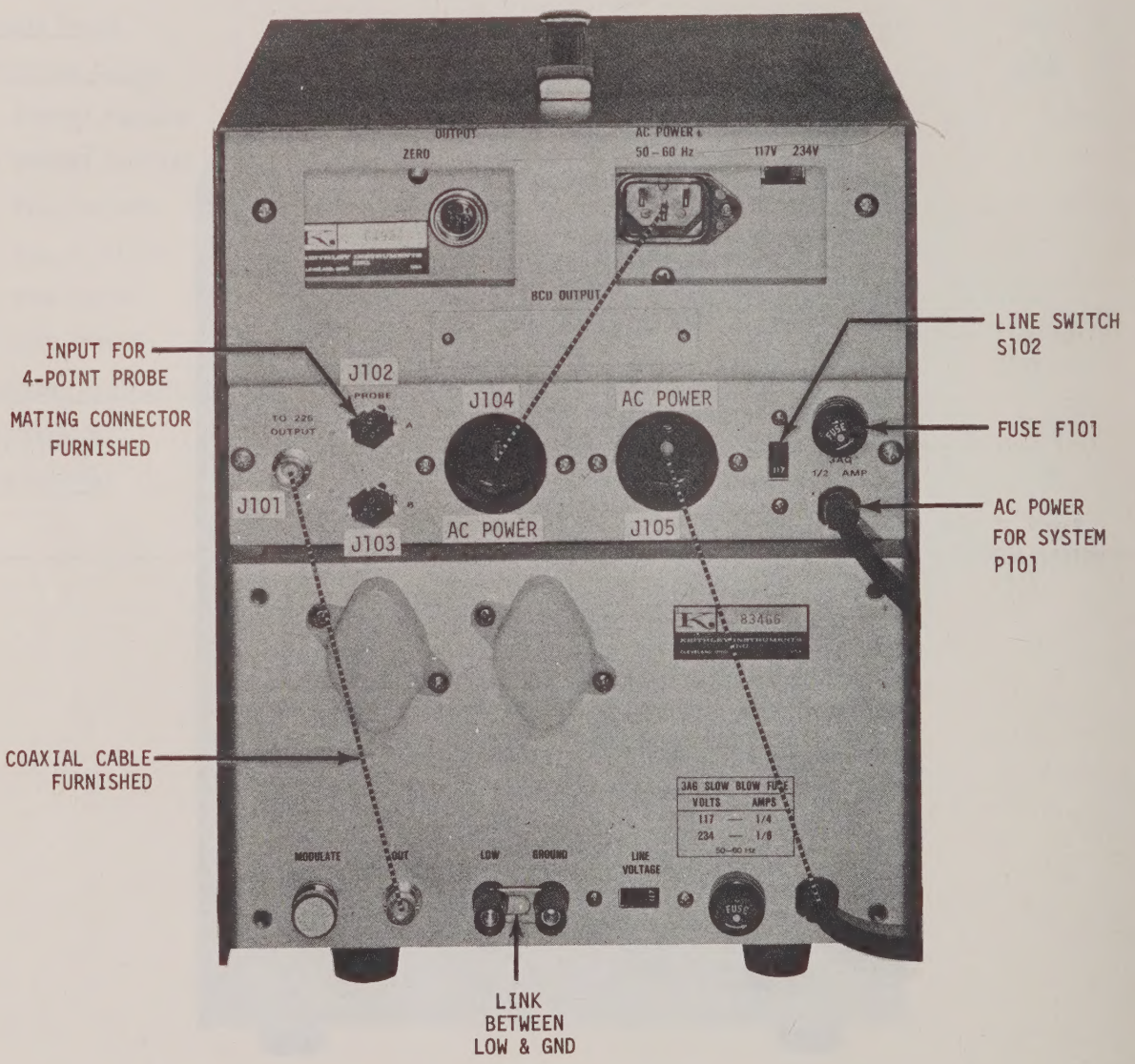


FIGURE 2. Rear Panel Connections.

SECTION 2. OPERATION

2-1. Resistivity Determination: The measurement of resistivity is accomplished through the use of 1) a constant current source, 2) a microvolt meter and 3) a four-point resistivity probe. Resistivity is scaled to give a direct reading in OHM-CM on a 100 mV scale (1 mV = 1 OHM-CM). Procedure:

a. Power. Connect the Model 530 to either 117 or 234V (Set line switch S102 to proper position). Check fuse F101 for proper rating. The Model 163 and 225 line cords should be connected to auxiliary power receptacles J104 and J105.

b. Control Settings.

1. Set the Model 225 as follows:

OUTPUT SELECTOR	-- STANDBY
FILTER	-- OFF
VOLTAGE COMPLIANCE	-- 50
Decade Switches	-- 0-0-0
Range	-- 100 μA
Power On	-- ON

2. Set the Model 163 as follows:

Range	-- 100.0 mV
Power On	-- ON

3. Set the Model 530 as follows:

FUNCTION	-- STANDBY
PROBE	-- A
CURRENT SHUNT	-- 1K
POWER	-- ON

c. Connections.

1. Connect Model 225 output to J101 on Model 530. (Connect shorting link between LO-GND on rear panel of Model 225.)

2. Connect Model 163 terminals to J106 (Red) and J107 (Black).

d. Calibration. Set the Model 225 for proper current depending on the slice dimensions of the sample. Table 2-1 gives the current setting for particular slice thickness and diameter (with probe tip spacing = 1.60 MM or 0.0630 inch).

e. Connection Check. Connect the probe and lower onto slice. Set the Model 530 to CURRENT function (Position 2). Adjust the Model 530 CURRENT SHUNT Switch to give the maximum on-scale reading on the Model 163. The voltage displayed on the 163 is a function of the current x R_{SHUNT}. The Model 163 should indicate the output which has been set on the Model 225 decade dials. For example, if the current has been set to 173.1 μA, the Model 163 should indicate 173.1 mV with the Model 530 Shunt Resistor set to 1K. Since the Model 163 is scaled for direct reading of resistivity, the reading could also be interpreted as 173.1 OHM-CM.

NOTE

If the Model 163 does not indicate the proper current the probe is probably not making proper contact to the slice. If the Model 225 LIMIT lamp is lighted then the probe connections are probably open.

f. Resistivity Measurement. Set the Model 530 to V_{FWD} function (Position 3) and record the reading on the Model 163. The display is scaled to indicate directly in terms of OHM-CM resistivity (1 mV = 1 OHM-CM). Since the resistivity measurement is dependent on slice geometry (thickness, etc.) the scaling is valid for the particular current selected from Table 2-1. If the slice dimensions are changed, a new current should be dialed out on the Model 225 to provide direct reading in OHM-CM. Set the Model 530 to V_{REV} function (Position 4) to obtain a reading with opposite polarity applied. The CURRENT SHUNT switch can be in any position since it does not affect the resistivity measurement.

2-2. Type Determination: The conductivity type can be determined by 1 of 2 methods: Rectification Mode or Thermoelectric Mode.

a. Rectification Mode. Set the Model 530 to TYPE (RECT) (Position 5). If the Model 163 indicates greater than 0.5 mV then the material type is determined by the polarity indicated on the Model 163.

Positive Polarity = P-type
Negative Polarity = N-type

If the reading is less than 0.5 mV then proceed to the Thermoelectric Mode.

b. Thermoelectric Mode. Set the Model 530 to TYPE (THERM) (Position 6). The Model 163 should indicate less than 0.5 mV. The material type is determined by the polarity indicated on the Model 163.

Positive Polarity = P-type
Negative Polarity = N-type

TABLE 2-1.
Typical Current Settings in μA.

Slice Diameter in MM	Slice Thickness in MM				
	0.1	0.2	0.3	0.4	0.5
16	41.7	83.4	125.0	166.6	208.2
17	42.1	84.1	126.1	168.1	210.1
18	42.4	84.8	127.1	169.4	211.7
19	42.7	85.3	127.9	170.5	213.1
20	42.9	85.8	128.7	171.5	214.3

(For other slice dimensions refer to Appendix.)

SECTION 3. CIRCUIT DESCRIPTION

3-1. GENERAL. The Model 530 provides all the controls, interconnections, and circuits necessary for making resistivity and semiconductor typing determinations using the "Type-A11" system.

3-2. EQUIPMENT USED. The Model 530 utilizes a Keithley Model 225 Current Source, a Model 160 or 163 Digital Voltmeter, and auxiliary ac power source. Separate circuit descriptions are provided in the individual Instruction Manuals for Models 163 and 225. The remaining circuits are described in the following paragraph.

3-3. SWITCHING OPERATION.

a. Standby Position. In this position the probe terminals are completely disconnected from the Model 530 circuitry.

b. Current Position. In this position the Model 163 and 225 are connected such that the Model 163 will indicate the voltage drop across one of the Shunt Resistors. For example, with the Model 225 set at 100 μA and a 1 kilohm Shunt Resistor selected, the Model 163 should indicate 100 mV if the probe points are making satisfactory contact.

c. V_{FWD} Position. In this position the Model 163 is connected so as to read the voltage drop across the semiconductor sample. The resistivity is indicated directly in terms of OHM-CM when the current setting is scaled properly.

d. V_{REV} Position. In this position the Model 225 polarity is reversed automatically so as to permit a reverse voltage across the sample. The Model 163 indicates the resistivity in terms of OHM-CM when the current setting is scaled properly.

e. Type (Rect) Position. In this position an ac voltage is impressed between terminals A and B. The Model 163 is connected between pins B and D.

f. Type (Therm) Position. In this position the Model 163 is connected between terminals C and D. The voltage which results from the Seebeck effect is measured at points separate from the impressed ac voltage points.

3-4. AC POWER SUPPLY. An ac voltage is provided by the 12.6V secondary winding of transformer T101. The primary windings are connected in parallel or in series depending on the position of the Line Switch S102. Resistor R101 provides short circuit protection for the secondary. Fuse F101 provides over-current protection for the primary of T101.

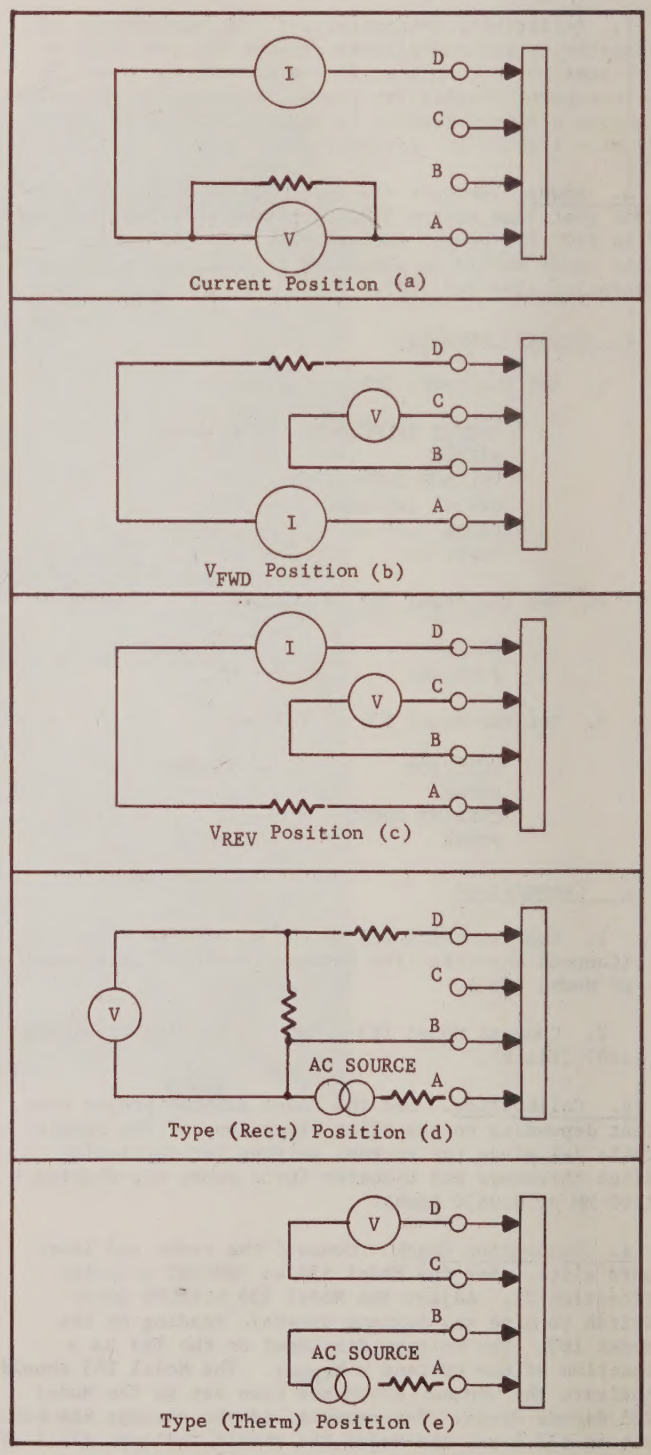


FIGURE 3. Type-A11 Circuit Connections

SECTION 4. REPLACEABLE PARTS

RESISTORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.
R101	25 Ω	5%, 5 W	WW	91637	RS-5	R4A-25
R102	1 Ω	0.1%, 1/4 W	WW	01686	7009	R95-1
R103	10 Ω	0.1%, 1/4 W	WW	01686	7009	R95-10
R104	100 Ω	0.1%, 1W	WW	02985	TS-1	R-249-100
R105	1 KΩ	.25%, 10 W	WW	94322	EL10A	R-231-1K
R106	10 KΩ	1%, 1/2 W	DCb	91637	DCF-1/2	R12-10K
R107	10 MΩ	1%, 1/2 W	DCb	91637	DCF-1/2	R12-10M

MISCELLANEOUS

Circuit Desig.	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.
F101	Fuse, Slo-Blo, 1/2A, 3AG	75915	312.500	FU-6
J101	Receptacle, BNC	95712	6672NT34	CS-15
J102	Receptacle			
--	Locking Ring, used with J102	02660	126-1428	CS-164
--	Nut, used with J102	02660	41-153	CS-160
J103	Receptacle			
--	Locking Ring, used with J103	02660	41-153	CS-160
--	Nut, used with J103	02660	41-153	CS-160
J104	Receptacle, Power	02660	1604	CS-248
J105	Receptacle, Power	02660	1604	CS-248
J106	Binding Post, Red	58474	DF21RC	BP11-RED
J107	Binding Post, Black	58474	DF21BC	BP11-BLK
P101	Line Cord	93656	4638-13	CO-5
S101	Switch, Toggle	80164	---	SW-236
S102	Switch, Slide (117-234V)	80164	---	SW-151
S103	Switch, Rotary	80164	---	SW-359
S104	Switch, Rotary	80164	---	SW-358
S105	Switch, Toggle	80164	---	SW-357
T101	Transformer	80164	---	TR-146
--	Knob, (For S103, S104)	80164	---	21660A
--	Front Panel	80164	---	24168B
--	Chassis Assembly	80164	---	24941B
--	Rear Panel	80164	---	24169B
--	Connector, Mate of J103	02660	126-1427	CS-162
--	Connector Body, used with CS-162	02660	126-1425	CS-161
--	Locking Ring, used with CS-162	02660	126-1430	CS-165
--	Connector, Mate of J102	02660	126-1427	CS-162
--	Connector Body, used with CS-162	02660	126-1425	CS-161
--	Locking Ring, used with CS-162	02660	126-1430	CS-165
--	Cover Assembly (225)	80164	---	25510B
--	Cover Assembly (163)	80164	---	24177B
--	Cable Assembly	80164	---	Model 8201

MODIFICATIONS:

The Model 160 or 163 as supplied with the Model 530 has been modified as follows:

Resistors R112 and R115 have been removed to increase the input resistance of the voltmeter on the 100 mV range.

Note: If the Model 160 is supplied the ohms function will not be useable on the 1 megohm and 10 megohm ranges unless the resistors (R112 and R115) are replaced.

APPENDIX A

Computer Program to Determine Current Setting

```
1: #.##  ####.# ####.# ####.# ####.# ####.# ####.# ####.# ####.# ####.#
2:INCHES   ##.#   ##.#   ##.#   ##.#   ##.#   ##.#   ##.#   ##.#   ##.#
3: DIAM                        SLICE THICKNESS IN MILS
4:                  TABLE ØF CURRENT SETTINGS IN MICRØAMPERES
5:                  TØ GIVE DIRECT READING ØF RESISTIVITY IN
6:                  ØHM-CM ØN THE 100 MV SCALE (1 MV = 1 ØHM-CM)
7:                  PRØBE TIP SPACING = ##.# MILS (=###.## MM)
8:ENTER PRØBE TIP SPACING IN MILS
9:SLICE THICKNESS IN MILS. START, FINISH, STEP (9 VALUES MAXIMUM)
10:SLICE DIAMETER IN INCHES. START, FINISH, STEP (.01 MINIMUM STEP)
11 DIM P(25)
20 DATA 0.997,0.992,0.982,0.966,0.944,0.921
21 FØR K= 0 TØ 5
22 READ Q(K)
23 NEXT K
30 DATA 4.532,4.531,4.528,4.524,4.517,4.508,4.497,4.485,4.470
31 DATA 4.454,4.436,4.417,4.395,4.372,4.348,4.322,4.294,4.265,4.235
32 DATA 4.204,4.171
33 FØR K=0 TØ 20
34 READ P(K)
35 NEXT K
100 PRINT USING 8
110 INPUT S
120 PRINT USING 9
130 INPUT T1,T2,T3
140 PRINT USING 10
150 INPUT D1,D2,D3
160 LET S1= S*25.4/1000
170 PRINT
180 PRINT USING 4
190 PRINT USING 5
200 PRINT USING 6
210 PRINT USING 7,S,S1
220 PRINT
230 PRINT
239 PRINT USING 3
240 LET T2=T2+0.000001
241 FØR T= T1 TØ T2 STEP T3
242 LET I=I+1
243 LET T(I)= T
244 NEXT T
250 PRINT USING 2,T(1),T(2),T(3),T(4),T(5),T(6),T(7),T(8),T(9)
251 PRINT
260 FØR D= D1 TØ D2 STEP D3
261 LET X=S/(D*1000)
262 LET Y= INT(X*200)
263 LET X1= X*200 -Y
264 LET F2= P(Y) + X1*(P(Y+1)-P(Y))
300 FØR J= 1 TØ I
310 LET X= T(J)/ S
311 IF X <= 1.0 THEN 320
312 PRINT "SLICE THICKNESS/PRØBE SPACING IS LARGER THAN ØNE"
320 IF X >= 0.5 THEN 400
330 LET F(J)= 1-(X*0.006)
340 GØTØ 450
400  LET Y= INT(X*10) - 5
410 LET X1= X*10 -5 -Y
420 LET F(J)=Q(Y) + X1*(Q(Y+1)-Q(Y))
450 LET A(J)= F2*T(J)*F(J)*2.54
460 NEXT J
470 PRINT USING 1,D,A(1),A(2),A(3),A(4),A(5),A(6),A(7),A(8),A(9)
480 NEXT D
```

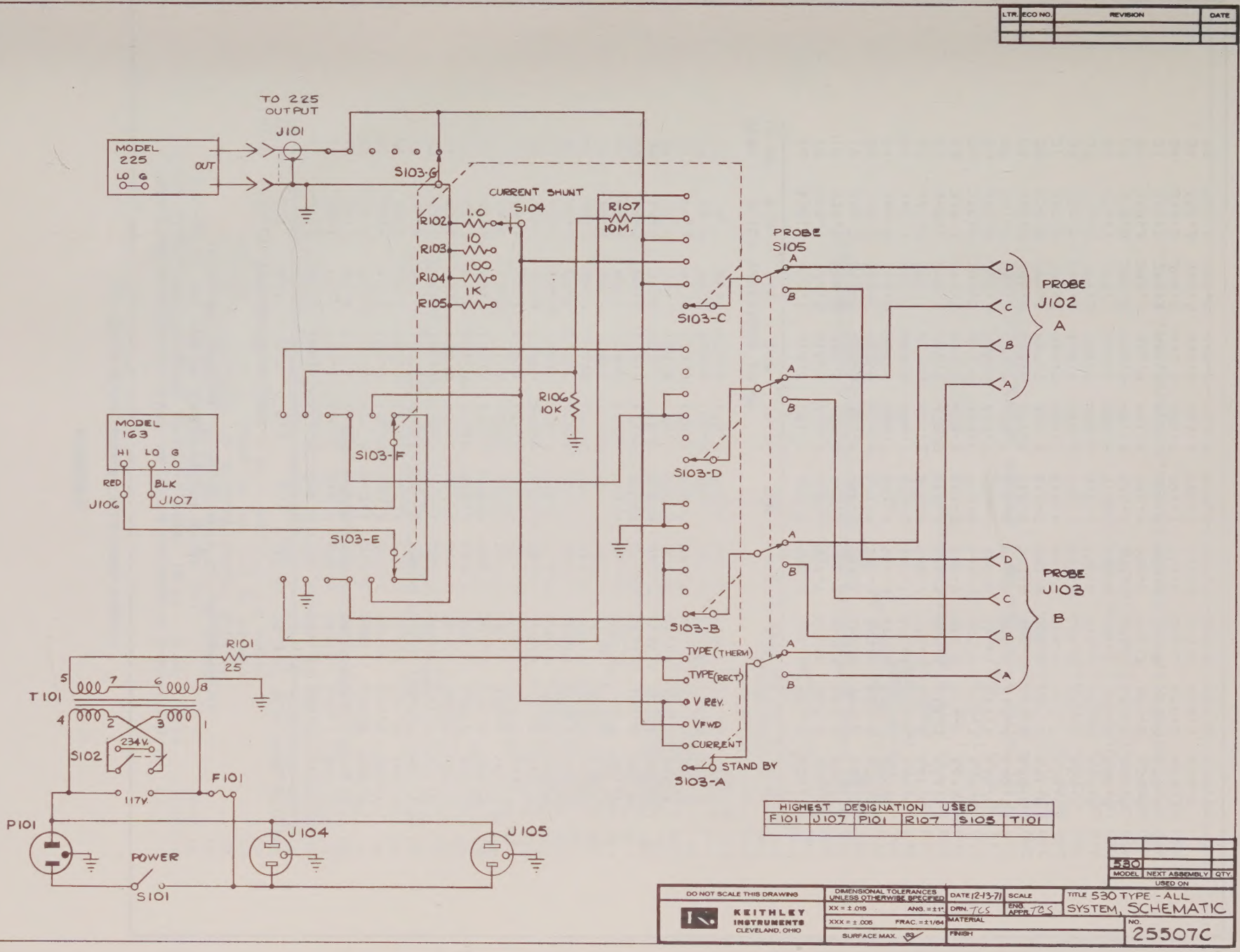
APPENDIX B

Table of Calculated Current Settings

TABLE ØF CURRENT SETTINGS IN MICRO-AMPERES
TØ GIVE DIRECT READING ØF RESISTIVITY IN
ØHM-CM ØN THE 100 MV SCALE (1 MV= 1 ØHM-CM)
PRØBE TIP SPACING = 1.60 MM (= 0.0630 INCH)

DIAM IN MM	SLICE THICKNESS IN MM 0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
16	41.7	83.4	125.0	166.6	208.2	249.7	291.2	332.7	373.1
17	42.1	84.1	126.1	168.1	210.1	252.0	293.9	335.7	376.5
18	42.4	84.8	127.1	169.4	211.7	253.9	296.1	338.3	379.4
19	42.7	85.3	127.9	170.5	213.1	255.6	298.1	340.5	381.9
20	42.9	85.8	128.7	171.5	214.3	257.1	299.8	342.5	384.1
21	43.1	86.2	129.3	172.4	215.4	258.3	301.3	344.2	386.0
22	43.3	86.6	129.9	173.1	216.3	259.4	302.6	345.7	387.7
23	43.5	86.9	130.4	173.7	217.1	260.4	303.7	347.0	389.1
24	43.6	87.2	130.8	174.3	217.8	261.3	304.7	348.1	390.4
25	43.7	87.5	131.2	174.8	218.4	262.0	305.6	349.1	391.5
26	43.9	87.7	131.5	175.3	219.0	262.7	306.3	350.0	392.5
27	44.0	87.9	131.8	175.7	219.5	263.3	307.1	350.8	393.4
28	44.1	88.1	132.1	176.0	220.0	263.9	307.7	351.5	394.3
29	44.1	88.3	132.3	176.4	220.4	264.4	308.3	352.2	395.0
30	44.2	88.4	132.6	176.7	220.8	264.8	308.8	352.8	395.7
31	44.3	88.5	132.7	176.9	221.1	265.2	309.3	353.3	396.2
32	44.3	88.7	132.9	177.2	221.4	265.6	309.7	353.8	396.8
33	44.4	88.8	133.1	177.4	221.7	265.9	310.1	354.3	397.3
34	44.4	88.9	133.2	177.6	221.9	266.2	310.4	354.7	397.7
35	44.5	89.0	133.4	177.8	222.2	266.5	310.8	355.0	398.2
36	44.5	89.0	133.5	178.0	222.4	266.7	311.1	355.4	398.6
37	44.6	89.1	133.6	178.1	222.6	267.0	311.4	355.7	398.9
38	44.6	89.2	133.7	178.3	222.7	267.2	311.6	356.0	399.2
39	44.7	89.3	133.9	178.4	222.9	267.4	311.8	356.3	399.5
40	44.7	89.3	133.9	178.5	223.1	267.6	312.1	356.5	399.8

DIAM IN MM	SLICE THICKNESS IN MM 0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6
16	332.7	373.1	412.7	451.1	487.5	522.3	554.5	585.2	614.6
17	335.7	376.5	416.5	455.3	492.0	527.1	559.6	590.6	620.3
18	338.3	379.4	419.7	458.8	495.8	531.2	563.8	595.1	625.1
19	340.5	381.9	422.5	461.8	499.0	534.6	567.6	599.0	629.2
20	342.5	384.1	424.9	464.4	501.9	537.7	570.8	602.5	632.8
21	344.2	386.0	427.0	466.7	504.4	540.4	573.6	605.5	635.9
22	345.7	387.7	428.8	468.7	506.5	542.7	576.1	608.1	638.6
23	347.0	389.1	430.4	470.5	508.4	544.7	578.3	610.3	641.0
24	348.1	390.4	431.8	472.0	510.1	546.5	580.1	612.3	643.1
25	349.1	391.5	433.1	473.4	511.5	548.0	581.8	614.1	644.9
26	350.0	392.5	434.2	474.6	512.9	549.5	583.3	615.7	646.6
27	350.8	393.4	435.2	475.7	514.1	550.8	584.7	617.1	648.1
28	351.5	394.3	436.1	476.7	515.2	551.9	585.9	618.4	649.5
29	352.2	395.0	437.0	477.6	516.2	553.0	587.1	619.6	650.8
30	352.8	395.7	437.7	478.4	517.0	553.9	588.0	620.6	651.8
31	353.3	396.2	438.3	479.1	517.8	554.7	588.9	621.5	652.8
32	353.8	396.8	438.9	479.8	518.5	555.5	589.7	622.4	653.7
33	354.3	397.3	439.5	480.4	519.1	556.2	590.4	623.2	654.5
34	354.7	397.7	440.0	480.9	519.7	556.8	591.1	623.9	655.2
35	355.0	398.2	440.5	481.5	520.3	557.4	591.7	624.6	656.0
36	355.4	398.6	440.9	481.9	520.8	558.0	592.3	625.2	656.6
37	355.7	398.9	441.3	482.3	521.2	558.4	592.8	625.7	657.2
38	356.0	399.2	441.6	482.7	521.7	558.9	593.3	626.2	657.7
39	356.3	399.5	442.0	483.1	522.1	559.3	593.8	626.7	658.2
40	356.5	399.8	442.3	483.5	522.5	559.7	594.2	627.2	658.7


LTR. ECO NO. REVISION DATE
TO 225 OUTPUT
J101
MODEL 225
LO G
OUT
S103-G
CURRENT SHUNT
S104
R102 1.0
R103 10
R104 100
R105 1K
R107 10M.
PROBE S105
S103-C
S103-D
S103-B
S103-A
PROBE J102 A
PROBE J103 B
R106 10K
MODEL 163
HI LO G
RED
BLK
J106
J107
S103-F
S103-E
R101 25
T101
S102
234V.
117V.
F101
P101
POWER
S101
J104
J105
TYPE (THERM)
TYPE (RECT)
V REV.
V FWD
CURRENT
STAND BY
HIGHEST DESIGNATION USED
F101 J107 P101 R107 S105 T101
530
MODEL NEXT ASSEMBLY QTY.
USED ON
DO NOT SCALE THIS DRAWING
DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED
XX = ± .015 ANG. = ±1°
XXX = ± .005 FRAC. = ±1/64
SURFACE MAX. 63
KEITHLEY INSTRUMENTS CLEVELAND, OHIO
DATE 12-13-71
DRN. TCS
ENG. APPR. TCS
SCALE
MATERIAL
FINISH
TITLE 530 TYPE - ALL SYSTEM, SCHEMATIC
NO. 25507C

KEITHLEY INSTRUMENTS, INC.

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